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SPIN-OFF BENEFITS OF SPACE TECHNOLOGY

Working paper submitted by China

China's space programme began in the 1960s. As the space programme has evolved, there has been an ever greater demand for new technologies, new materials, new sources of energy and new equipment. Accordingly, proceeding from the principle of self-reliance, China has identified corresponding projects for study by many of its scientific research and manufacturing establishments, thus greatly promoting development and progress in many fields, e.g., materials, electronics, machinery, chemicals and metallurgy. Over 4,000 projects inspired by developments in space technology have now been completed in such areas as computers, integrated circuits, lasers, optical fibres, high-temperature alloys, titanium alloys, new composites and rare gases. This has not only ensured the successful implementation of China's space programme, but also gives impetus to the development of China's high-tech manufacturing industry. China's space technology consists primarily of control technology, temperature-control technology, telemetry and remote-control technology, remote-sensing technology, radio technology, space environment simulation technology and measurement technology. Achievements in hundreds of projects employing these technologies have been applied in traditional manufacturing industries, yielding immense economic benefits. Thus, the development of space technology in China has not only had direct benefits for various sectors of the national economy in such areas as communications and remote sensing, but has significant spin-off benefits as well.

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I. EXTENDING SPACE TECHNOLOGY APPLICATIONS

Various space technologies have been adapted for extensive use in the following areas:

1. Industrial automated measurement and control technology

The Chinese Academy of Space Technology (CAST) has successfully developed the STD5000-series industrial controller, developed and produced nearly 100 different modules, and developed over 20 software packages, which have wide-ranging applications in various industrial systems.

China's aerospace agencies have developed an interface standard for computer-based automated measurement and control (CAMAC), and have developed and produced more than 100 different functional modules, which in various combinations have potential applications in many areas. In particular, they have been used effectively in power-grid measurement and control in power stations.

Because satellite-borne computers must have long life and high reliability, error-tolerant and self-adapting technology is employed. An error-tolerant measurement and control system based on three computers has been developed which has been used in production lines in oil refineries, water-supply plants and breweries.

Radio telemetry and remote-control technology along with data collection and control technology developed on the basis of satellite-borne computer technology have now been extended to applications in oilfields and oceanographic buoys.

Industrial controllers for robot welders developed from computer and control technology have found applications in production assembly lines.

2. Development and application of remote-sensing and electronics technologies

A medical X-ray television system has been developed using remote-sensing imaging technology and electronics technology. This system has the advantage of low radiation damage and high resolution, and is well suited to clinical diagnosis. It is now in use in many hospitals both in China and abroad.

A train-axle thermal radiation detector has been developed using satellite infrared detection technology. It can quickly determine train-axle temperatures over a wide range, providing very effective early warning of failure. This detector is now widely used in railway systems.

Remote-sensing equipment and image-processing technology developed for satellite remote sensing are being employed in aviation, achieving good

results in resource and oceanographic surveying, disaster monitoring and forecasting, crop-yield prediction, etc.

3. Development and application of temperature-control and vacuum technologies

By the late 1970s, satellite temperature-control technology was already being used in the development and utilization of solar energy and energy conservation. Much technical experience has been gained in cold storage and temperature-control architectural design.

The heat-pipe technology used in satellite temperature control has been used on the ground since the late 1970s. A variety of products - heat-pipe thermal exchangers, heat-pipe black bodies, heat-pipe thermostats, heat-pipe solar collectors and heat-pipe energy-saving boilers - have been developed. These products are used extensively in the electronics, instrumentation, textile, chemical, casting, boiler-making and other industries as well as in everyday life.

The magnetic coupling and drive technology developed from satellite component vacuum testing technology offers the advantage of good sealing, no leakage and an appropriate transmission torque. It is therefore widely used in the petroleum, chemical, atomic energy, hospital and food-processing sectors.

II. PROCESSING TECHNOLOGIES AND OTHER NEW TECHNOLOGIES IN THE SPACE INDUSTRY

1. Processing technologies

Ion-beam etching is an ultra-precision processing technology developed for the processing of space materials. This technology has the advantage of producing etched patterns with extremely high resolution, controllable groove-depth and groove-wall inclination, and low surface stress. It has become an effective tool in China for the research and production of many new devices, such as large-scale integrated circuits, acoustic surface-wave devices, magnetic bubble devices, microwave devices and superconducting devices.

Aerospace precision processing technology and computer-based automated manufacturing technology have been employed in the processing of high-precision, fine-finish equipment, such as electron accelerators for medical use, moulds for camera lenses, and magnetic drums for video recorders.

2. Extending the application of new technologies

Adapting the new processing technologies that have been developed for space manufacturing to other industries will result in a vast improvement over existing technologies. Technologies such as microprocessor self-adapting electric spark processing, stainless steel welding, cold welding of cast iron, casting of one-piece hollow casings, shape adjustment by mechanical rolling, linear cutting of very thick workpieces, isothermal superplastic forming, sealing, spray-coating and deep refrigeration used in space manufacturing have been applied in various civilian industries. For example, by substituting titanium alloys for heat-resistant alloys and employing isothermal superplastic forming technology to make turbine disks for gas-turbine generators, efficiency can be improved 20 times, while cost can be cut by 90 per cent.

3. Technologies used in the non-destructive testing of composite materials

Non-destructive technologies for testing aerospace composite materials, including X-ray, ultra-sound, laser holography, acoustic emission and C-scanning, are gradually being extended to civilian use in areas in which composite materials are used.

III. EXTENDED USES OF SPACE MATERIALS, COMPONENTS AND PARTS

Space technology requires a wide variety of high quality materials, components and parts. This prompted China to pursue the development of its materials, electronics, machinery and other industries as early as the 1960s, and a majority of the products are currently being used in various industries. For example, microcrystalline glass developed in the early stages for launching vehicles can withstand high temperatures, is resistant to ablation, and has good radio-wave transmissivity. At present, this material is not only used in the aerospace industry, but is also used extensively in microwave ovens and electromagnetic stoves for civilian use. It is also used as substrate material for high-power microwave tubes and as casings for standard atomic frequency hydrogen clocks.

Ultra-thin molecular film, a new insulating material which is resistant to radiation, high temperature and corrosion, is now widely used in the electronics, electric cable and chemical industries.

As far back as the 1970s, composite materials were already widely used in the aerospace industry. They include carbon-fibre composites, glass-fibre composites, high silica-fibre composites, ceramic-based composites and three-directional carbon-carbon composites. Of these, carbon-fibre and glass-fibre composites are now widely used in civilian industries.

The gyroscope is a key component in aerospace control systems. Now also used in railway systems, it permits very quick and accurate detection of unevenness in railway tracks.

Development of solar batteries and nickel-cadmium batteries began in the 1960s. They were first used in the second satellite launched by China in 1971, and have been used in communication satellites and meteorological satellites. Since the 1980s, they have been mass-produced as civilian power-source products - for example, as an emergency source of power for public buildings. Furthermore, high-performance silver-zinc batteries used in launch vehicles and satellites are also being mass-produced as civilian power sources.

The servo-controlled valve used in launch vehicles has been widely used in machine tools, robots, rolling mill and material testing machines. Air bearings, sensors, flow meters, etc., that are used in rockets are also widely used in various industries. For example, an instrument for measuring changes in blood flow developed using static-pressure air bearings and non-contact sensor technology is now used in many hospitals.

CONCLUSION

For more than 30 years, China's space programme has followed the principle of self-reliance, with support from various industrial sectors in the country, and extending over many fields of technology. Spin-off benefits from the extended application of technological achievements to other areas are substantial. China is continuing to exploit further its advantages in this field, so that space technology can be extended and transferred to civilian industries more effectively and quickly. China's aerospace agencies wish to enhance exchange and cooperation with all friendly nations so that they can jointly contribute to the peaceful use of outer space by all mankind.